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6
INSTALLATION CONSIDERATIONS

Several factors need to be considered to select the proper DGPS broadcast site location and insure adequate installation of the equipment at the broadcast site. Although a common set of equipment is used at each DGPS broadcast site, some aspects of the installation are specific for a particular site, depending on local conditions. This chapter presents an overview of the factors that will affect the successful installation of a broadcast site, but does not cover the detailed engineering information required to complete the installation. Refer to the U.S. Coast Guard "Differential GPS Broadcast Equipment Technical Manual," GCF-W-1216-DGPS, and related documents for detailed information.

6.1 Site Selection

When determining the suitability of a location for use as a DGPS broadcast site the following factors should be considered:

(a) A geographical location near the location recommended in chapter 5. It should be noted that the recommended DGPS broadcast site locations that have been added to complete the nationwide coverage were selected as optimum locations and at these frequencies, location of the site up to 10 miles from the optimum location will have very little effect on the nationwide coverage plan.

(b) Access to the site by construction and maintenance crews.

(c) Availability of space for a new equipment shelter or existence of a suitable building to serve as a shelter.

(d) Suitability of the site for installation of the radiobeacon transmitting antenna and associated equipment, or existence of a previously installed transmitting antenna.

(e) Availability of suitable reference mast locations.

(f) Physical security of the site.

(g) Legal and environmental issues.

6.2 Site Configuration

The equipment required for a DGPS broadcast site is shown in Figure 6.1. The location selected for the broadcast site must be capable of accommodating this suite of equipment.

The typical layout of an existing GWEN radio transmitter site is shown in Figure 6.2. These existing GWEN radio transmitter sites, recommended for use as DGPS broadcast sites, are listed in Tables 5.2 and 5.4. The drawing shows a typical site and the layout at an individual site may vary due to local topography and site conditions. Additional sites that are required to complete the nationwide DGPS service will have a similar layout, with variations due to local conditions. The DGPS broadcast site element requiring the most area is the broadcast antenna tower and its associated ground plane. At new installations the antenna and ground plane will be designed, considering transmitter power available, antenna efficiency, and local ground conductivity, to provide the specified signal level at a distance of 10 kilometers from the transmitter. Therefore, at new installations the broadcast antenna design will be the determining factor in site layout.

6.3 Broadcast Antenna Installation

The installation of DGPS broadcast sites at existing GWEN radio transmitter sites, listed in Tables 5.2 and 5.4, will not require installation of a broadcast antenna, since an adequate antenna is in place at these sites. New installations, listed in Tables 5.3 and 5.4, that are necessary to complete the nationwide DGPS service, will require that a broadcast antenna and the associated ground plane be designed for the specific site. The antenna will vary to meet the requirements at an individual DGPS broadcast site. The USCG uses a variety of antennas at their DGPS broadcast sites including 60-foot towers, 90-foot towers, 150-foot towers, and 200-foot dual tower systems, depending on the requirements of an individual site. At new installations the antenna and ground plane will be designed, considering transmitter power available, antenna efficiency, and local ground conductivity, to provide the specified signal level at a distance of 10 kilometers from the transmitter.

6.4 Reference Mast Installation

This information will assist in selecting the most reasonable locations for the reference masts that support the GPS antennas. Four GPS antennas, on two reference masts, will be located at each broadcast site, two each for the redundant reference stations and integrity monitors. These four antennas will be mounted in pairs at two locations per site. Each pair will consist of one reference station antenna and one integrity monitor antenna. Under normal operating conditions, the reference station antenna at one location will be used with the integrity monitor antenna at the other location. This is done to reduce the similarity in the multipath received at the reference station and the integrity monitor. The greater the separation between the antennas, the less similarity there will be, the maximum distance practicable should be used. As a general rule, there must be at least a 22-meter distance between the locations of the reference station/integrity monitor antenna pairs. There may be sites where extraordinary considerations will override this desired separation. An offset in the height of the antennas, even of a few feet, will provide some

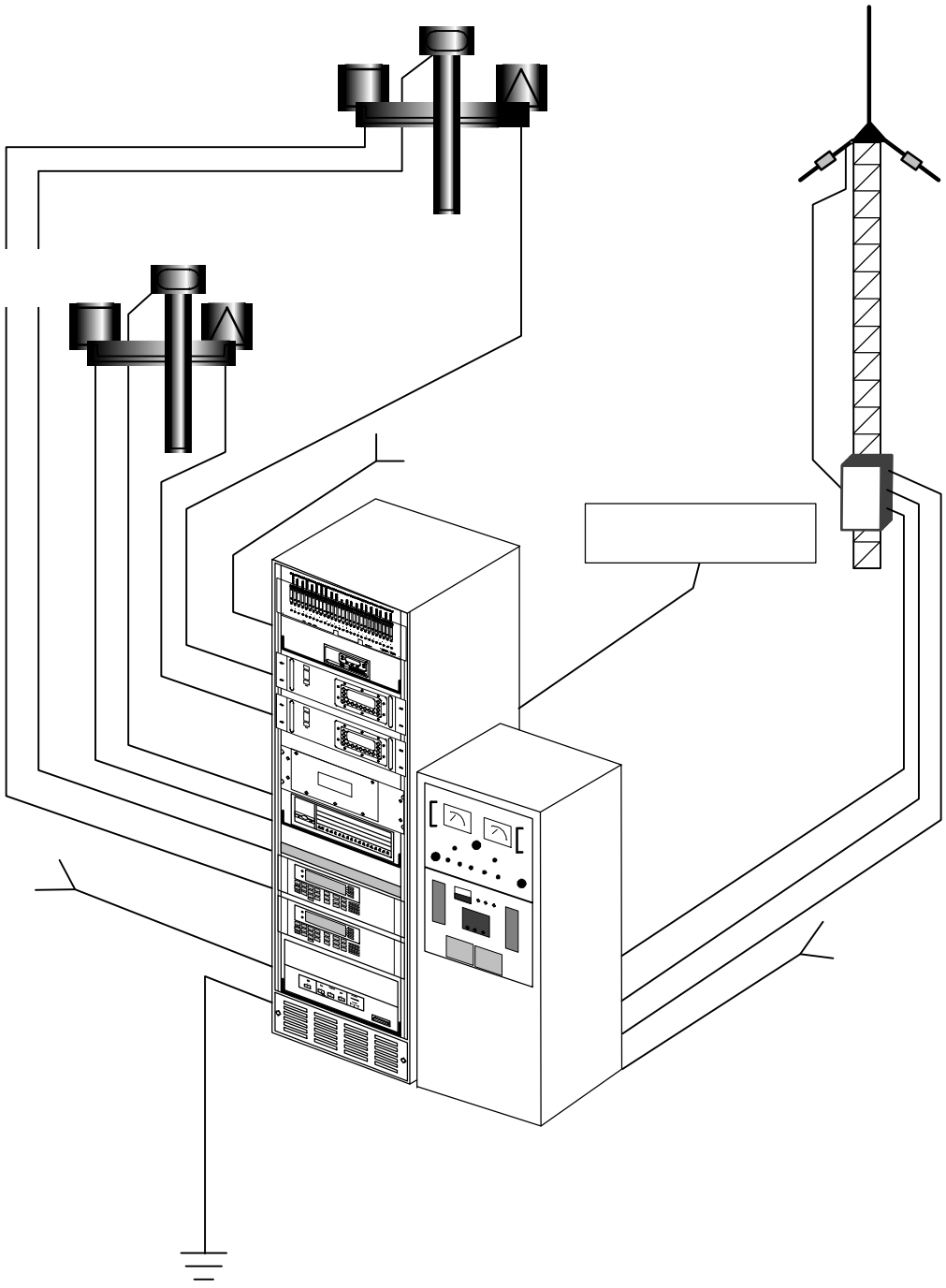

Figure 6.1. DGPS broadcast site equipment .

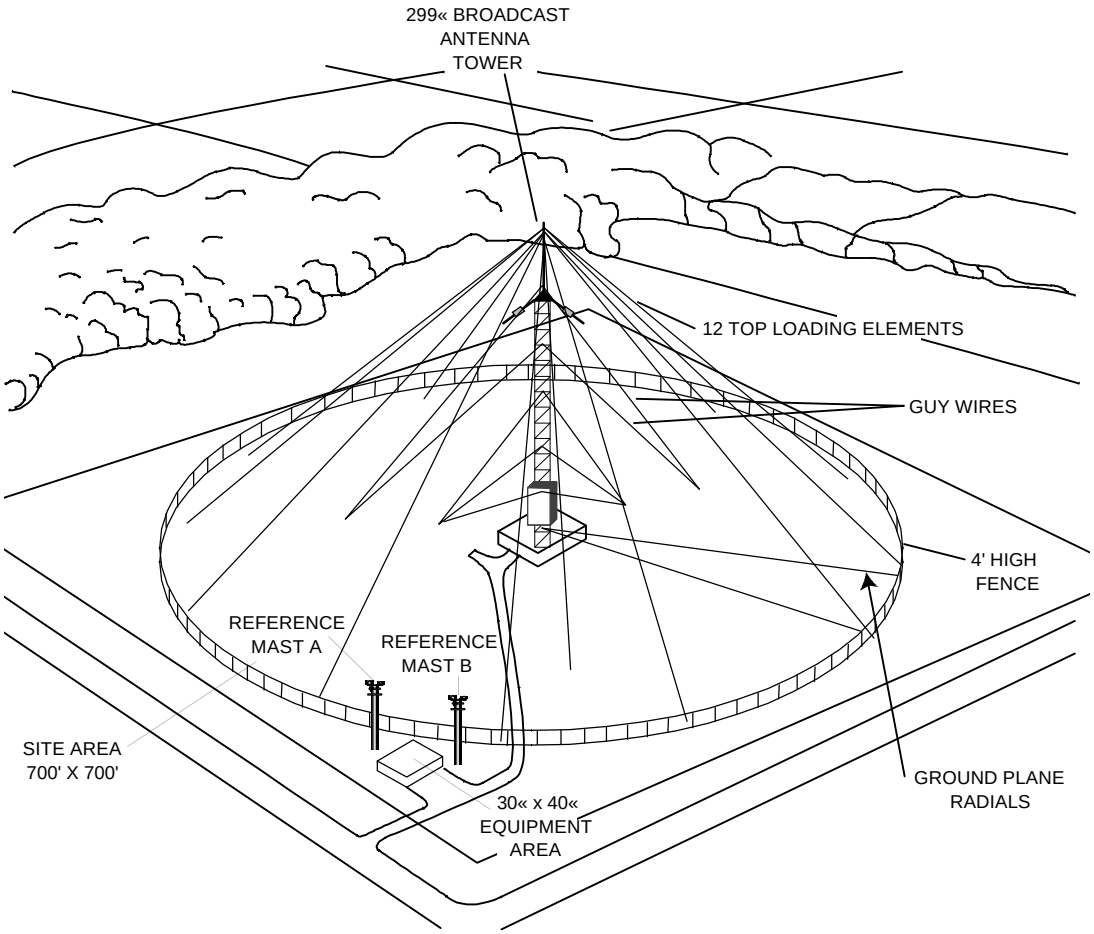

Figure 6.2. Typical existing GWEN radio transmitter site layout.

additional protection. Typically, GPS antennas will be mounted on 3- or 6-meter reference masts. In some cases, higher reference masts may be required to reduce horizon blockage and multipath effects. The reference masts must be sufficiently sturdy to keep sway within ±8 cm.

Due to the nature of the GPS satellite orbits and signal structure, there are two main concerns related to antenna placement. Since the satellites appear in all areas of the sky, shading due to hills, buildings, trees, and other obstructions should be minimized as far as practical. Sky blockage below 7.5 degrees of elevation is not a major concern, because corrections will only be broadcast for satellites above this mask angle. However, it should be noted that satellites below the mask angle will be tracked so that corrections will be ready when they rise above 7.5 degrees. In addition, steps must be taken to reduce the effects of multipath. Multipath effects are caused by reflected signals arriving at the antenna. These reflections are referred to as indirect signals. The signal arriving straight from the satellite is called the direct signal. The best case is when the direct signal is much stronger than all indirect signals combined.[11]

The antenna mounting requirements at each site will be unique depending on the local terrain, existing buildings, and other structures. Once the approximate location for the GPS antennas is determined, an optimum mount must be selected. Antenna mounts will either consist of hardware for attaching the antennas to existing buildings or towers, or require new reference masts

The distance between GPS antenna masts is a trade-off between cable length (30 meters maximum) and reducing the similarity of the multipath environments of the reference station and the integrity monitor. Due to the limited cable length, the antennas will be mounted relatively close to each other. The integrity monitor will notice if the multipath errors are large enough to throw the overall system performance out of tolerance. The integrity monitor will detect a problem for a single satellite whenever more than two satellites are being tracked.

6.5 Survey Requirements

The ability of the DGPS broadcast site to calculate and transmit accurate corrections to the GPS positioning signal relies on knowledge of the exact position of the GPS receive antennas located at the site. The procedure used by the USCG to survey these antenna positions at their existing DGPS broadcast sites is outlined below.

The National Geodetic Survey (NGS) installs geodetic monuments at the DGPS broadcast site to support the surveying of GPS antenna positions. These monuments are permanent survey markers. Two monuments are typically selected with significant separation, this reduces the chance both might be accidently destroyed by construction equipment or erosion. It is also desirable that one be in a publicly accessible location, and the other in a secure location where equipment can be left unattended. It is also desirable, but not required, that the monuments be visible from each other so that surveyors may use traditional optical methods to determine azimuths by using both. Distance of the monuments from the reference station/integrity monitor
reference masts should be kept under a few hundred meters.

Using these monuments, the position of each GPS antenna will be surveyed to determine its exact location within 10 cm. The position survey will use the North American Datum of 1983 (NAD-83). The reference stations GPS antennas geodetic positions must be surveyed to within ±10 cm in order to begin DGPS broadcasting. After the installation, NGS can analyze data in order to verify and refine the initial position survey to ±1 cm or better.

6.6 Shelter Requirements

If the DGPS broadcast site is being installed at an existing GWEN radio transmitter site (Tables 5.2 and 5.4), shelters suitable for equipment installation are available. For new DGPS broadcast site installations (Tables 5.3 and 5.4), a shelter to adequately house the DGPS equipment must be provided. Where possible, existing buildings or shelters should be utilized. If a new shelter is required, a fiberglass building with dimensions: 8 feet high, 15 feet wide, and 10.5 feet deep, is recommended, assuming an emergency power generator does not exist.

6.7 Equipment Rack Installation

The DGPS equipment rack and the radiobeacon transmitter rack should be installed inside the equipment shelter, allowing adequate working space on all sides of the racks. The preferred placement is to locate the DGPS equipment rack to the left of the radiobeacon transmitter, as shown in Figure 6.1. If possible the equipment rack should be mounted on a pedestal that will allow AC power to enter the rack through the base. If the AC power cannot be routed through the base of the rack it may be brought into the top of the rack. At the existing GWEN radio transmitter sites, equipment racks are in place, and the DGPS equipment and the radiobeacon transmitter may be mounted in these racks. Detailed instructions for installing the DGPS equipment in the racks, and interconnecting the equipment can be found in the U.S. Coast Guard "Differential GPS Broadcast Equipment Technical Manual."

6.8 Communications Requirements

One high-speed data line is required at the DGPS broadcast site to permit communication with the control station. This is an X.25, 9600 bps, 4-wire line supplied by the local service provider. One voice telephone line should be available for voice communications. These communication lines are brought into the equipment shelter.

6.9 Power Requirements

The DGPS broadcast site requires 115/230 VAC, 60 Hz commercial power as the primary power source. The radiobeacon transmitter rack, DGPS equipment rack, antenna tuning unit, lighting, service outlets, and environmental control systems should all have dedicated circuit breakers. The power requirements for the radiobeacon transmitter is determined by the equipment used at a particular location. If a USCG radiobeacon transmitter is used the power requirement varies from

450 VA to 6400 VA, depending on the transmitter power. Similar variations would be expected for other transmitters that might be used. The antenna tuning unit associated with each radiobeacon transmitter requires from 15 VA to 60 VA. The DGPS equipment rack requires a 20 amp circuit breaker. Circuit breakers for lighting and service outlets should be 20-amp. The power requirements for environmental controls are site specific and should be determined during design of the site. A power conditioner and filter should be part of the overall site design. This equipment will mitigate potential problems caused by brownouts, power fluctuations, and noise on the commercial power line. The required power is available at all existing GWEN radio transmitter sites.

An uninterruptible power system is required at each DGPS broadcast site to provide on-line uninterruptible AC power to the vital equipment located in the DGPS equipment rack. The uninterruptible power system does not provide uninterruptible power to the equipment rack cooling fan or the radiobeacon transmitter. The standard USCG DGPS broadcast site uninterruptible power system has a battery backup unit, located directly above, which will provide a minimum of 10 minutes power at full load. In the event of a loss in primary power, the uninterruptible power system will give the DGPS broadcast site monitor time to notify the control station of the site's power status but will not, by itself, allow the site to continue DGPS broadcasts. If the DGPS broadcast site is installed at an existing GWEN radio transmitter site the uninterruptible power system and battery backup unit will be available external to the DGPS equipment rack. In this case, the external uninterruptible power system should be incorporated into the DGPS system to support operation in the event of power failure.

At any DGPS broadcast site where power is not reliable, an emergency generator should be installed to provide sufficient backup power to the radiobeacon and DGPS rack in the event of a prolonged commercial power outage. The generator should be rated between 125 and 165 percent of the site's load, including environmental controls. At the existing GWEN radio transmitter sites this emergency generator is available, along with above ground fuel storage tanks.

6.10 Environmental Sensors

Environmental sensors are installed at each DGPS broadcast site so that conditions at the site can be monitored by the control station. The normal set of sensors include temperature sensors, humidity sensors, fire detection, and intrusion detection.

The temperature sensor is normally set to provide alarms if the temperature inside the shelter is above 90 degrees F or below 40 degrees F.

The humidity sensor is normally set to alarm if the humidity inside the shelter exceeds 80%.

The fire detectors are connected to the fire detection/suppression system. This installation will vary from site to site depending on the type of fire detection/suppression system installed.

The intrusion detectors are normally connected to the primary entrance and any windows in the shelter, to alarm on unauthorized entry. In areas where the DGPS equipment is located with other equipment, the intrusion detectors may be mounted on the DGPS equipment rack doors.

All of the environmental sensors described above are available at existing GWEN radio transmitter sites listed in Tables 5.2 and 5.4.

6.11 Fire Detection/Suppression

If a DGPS broadcast site is unmanned, it should be equipped with a fire detection/suppression system. The DGPS broadcast site monitor is designed to monitor the fire detection status and provide an alarm to the control station.

6.12 Physical Security

The DGPS broadcast site should be provided with security measures that will restrict access to the site and equipment on the site. Security fencing is available at all GWEN radio transmitter sites.

6.13 Broadcast Antenna Tower Lights

The requirements for broadcast antenna tower lighting will depend on the antenna tower used at a DGPS broadcast site. The 299-foot towers that are located at the existing GWEN radio transmitter sites are equipped with a white strobe light at the top to comply with Federal Aviation Administration safety standards.

6.14 Frequency Assignments

The radiobeacon transmitters operate in the 285 to 325 kHz, medium frequency band. This is a shared band, allocated for radionavigation applications, with civil and Government users in the band. The operating frequencies recommended for new DGPS broadcast sites have been selected to avoid interference with other DGPS broadcast sites and with Federal Aviation Administration beacons, civil radiobeacons licensed by the Federal Communications Commission, Canadian DGPS beacons, and Canadian aviation beacons, that operate in this frequency band. The recommended new frequencies are noted in Tables 5.1 through 5.4. Since frequency assignments in this band are dynamic, the situation will need to be reevaluated when application for a frequency assignment is made at a specific location.